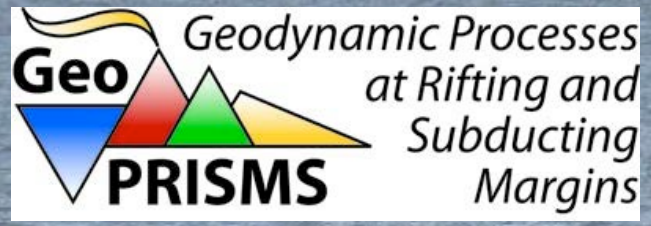
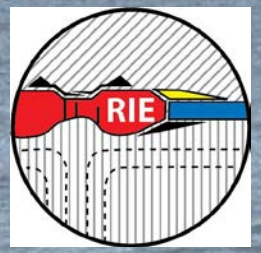
GeoPRISMS Rift Initiation and Evolution Initiative

Donna Shillington, LDEO

Other RIE TEI 2017 conveners: Tobias Fischer (U. New Mexico), Estella Atekwana (U. Delaware), Rebecca Bendick (U. Montana), Juliet Biggs (Bristol), Esteban Gazel (Va Tech), Liz Hajek (Penn State), Luc Lavier (UTIG)



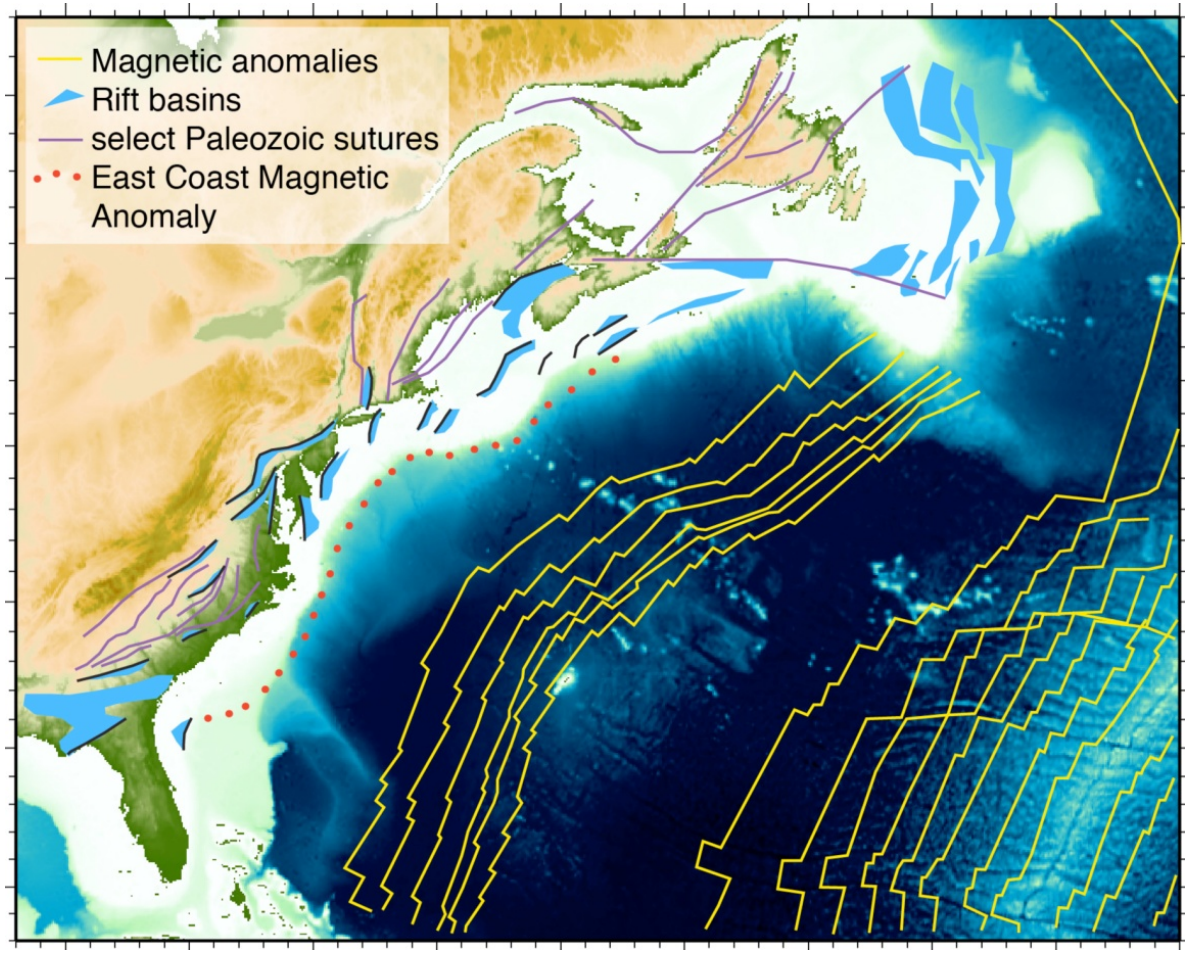


GeoPRISMS RIE science questions

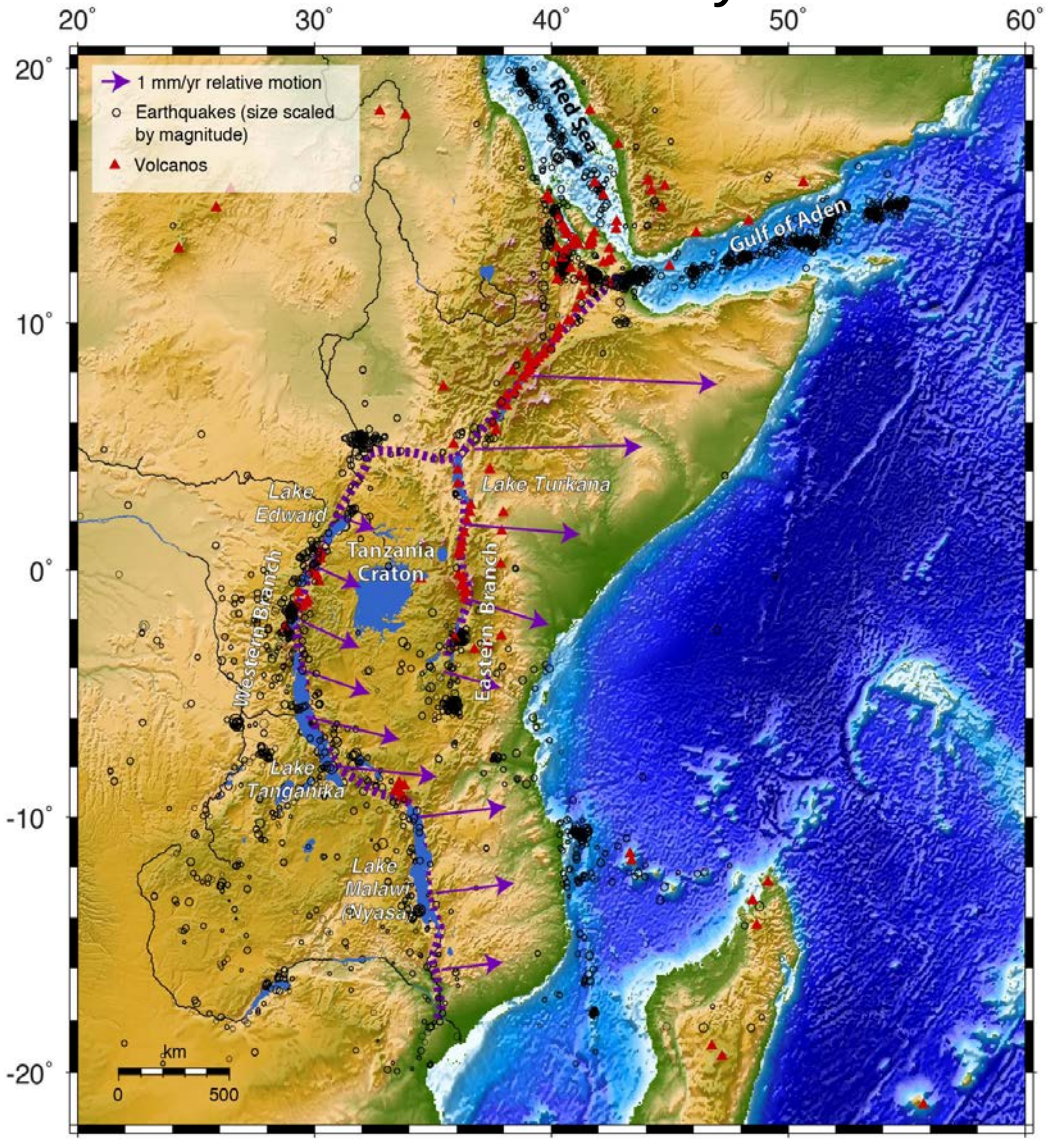
- Where and why do rifts initiate?
- How does deformation evolve in space and time?
- What controls the architecture of rifts?
- What are the mechanisms and consequences of volatile exchange at rifts?

Two primary sites

Eastern North American Margin



East Africa Rift System



Rationale for selected primary sites

ENAM:

- Passive rifted margin provides opportunity to consider full rifting evolution to seafloor spreading and rich postrift evolution
- Large along-strike variability in magmatism, rifting process and possible climate-tectonic interactions
- Leverages EarthScope and USGS activities

EAR:

- Encompasses full suite of stages in active rift development, including earliest stages
- Large along-strike variability in magmatism, deformation, maturity, possible climate-tectonic interactions
- Leverages other US and international efforts/programs in East Africa

Together:

- One active, one ancient system
- Interesting differences, opportunities for comparison

Thematic studies

Not all questions about rifts can be addressed in any two primary sites. The Science Plan also highlighted these as high-priority topics that also would enable linkage to MARGINS sites:

- Rift obliquity
- Rift processes as a function of strain rate
- Volatiles in rift zone processes
- Sediment production, routing and transport during and after rifting
- Discrete events at rifted margins

Planning and meetings

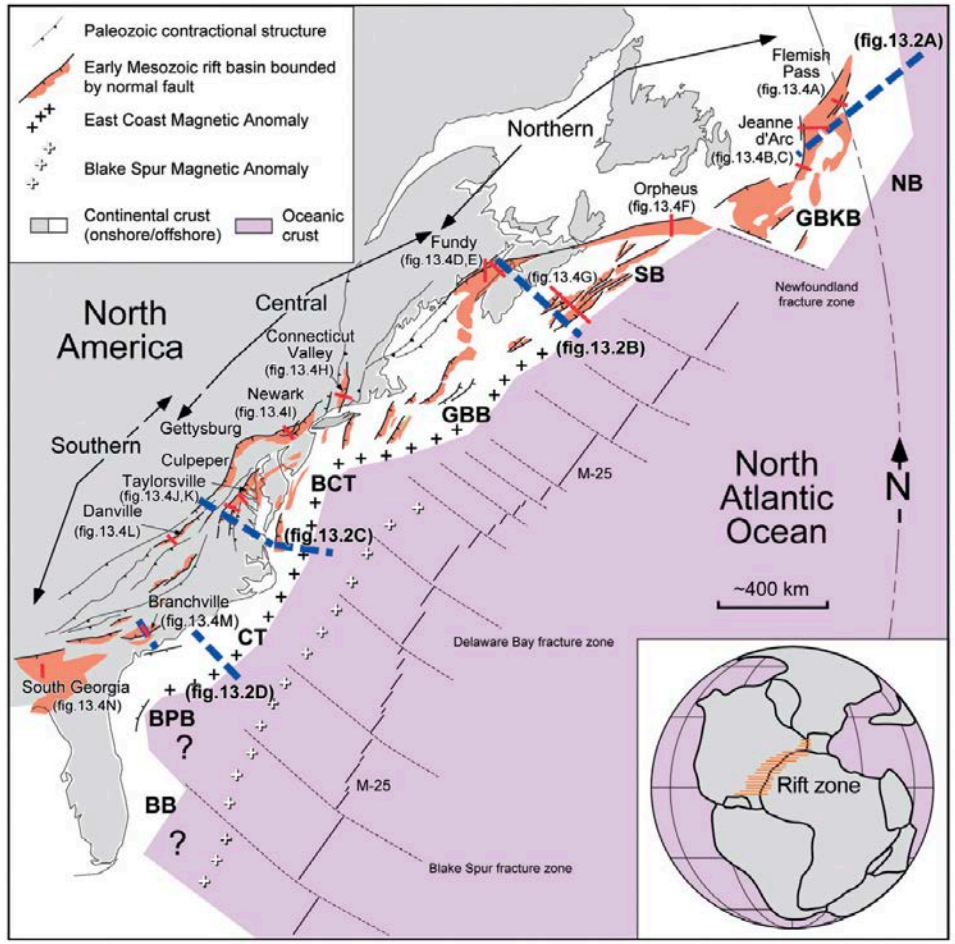
- Nov 2010: RIE Implementation Workshop, Sante Fe, NM
- Oct 2011: ENAM Implementation Workshop, Bethlehem, PA
- Oct 2012: EARS Implementation Workshop, Morristown, NJ
- 2015: GeoPRISMS Midterm Review
- Feb 2017: RIE TEI, Albuquerque NM
- Feb 2019: This meeting

Phased funding

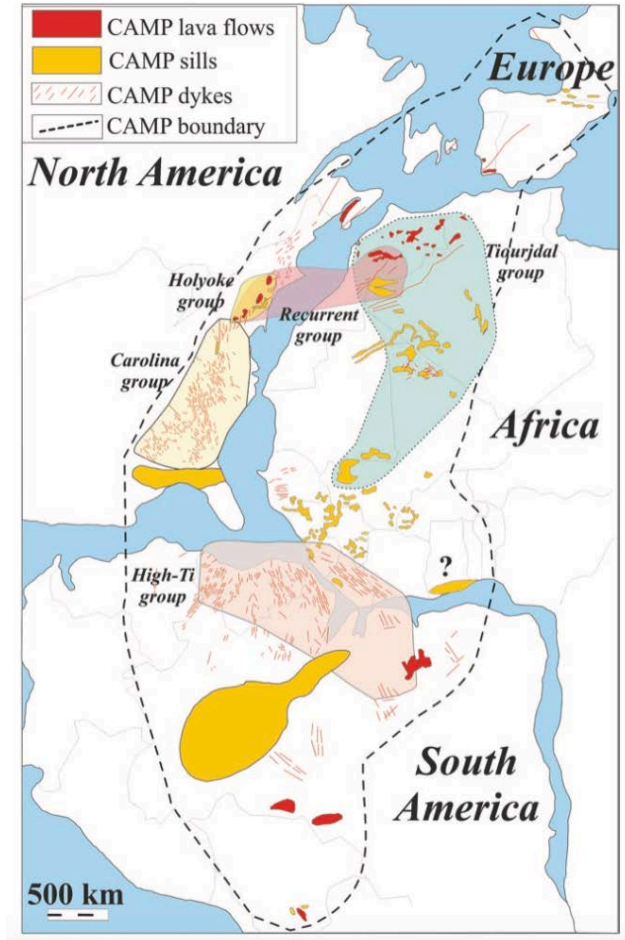
GeoPRISMS adopted phased funding model for major field efforts in primary sites.

- ENAM: ~2012-2013
- EARS: ~2014-2015

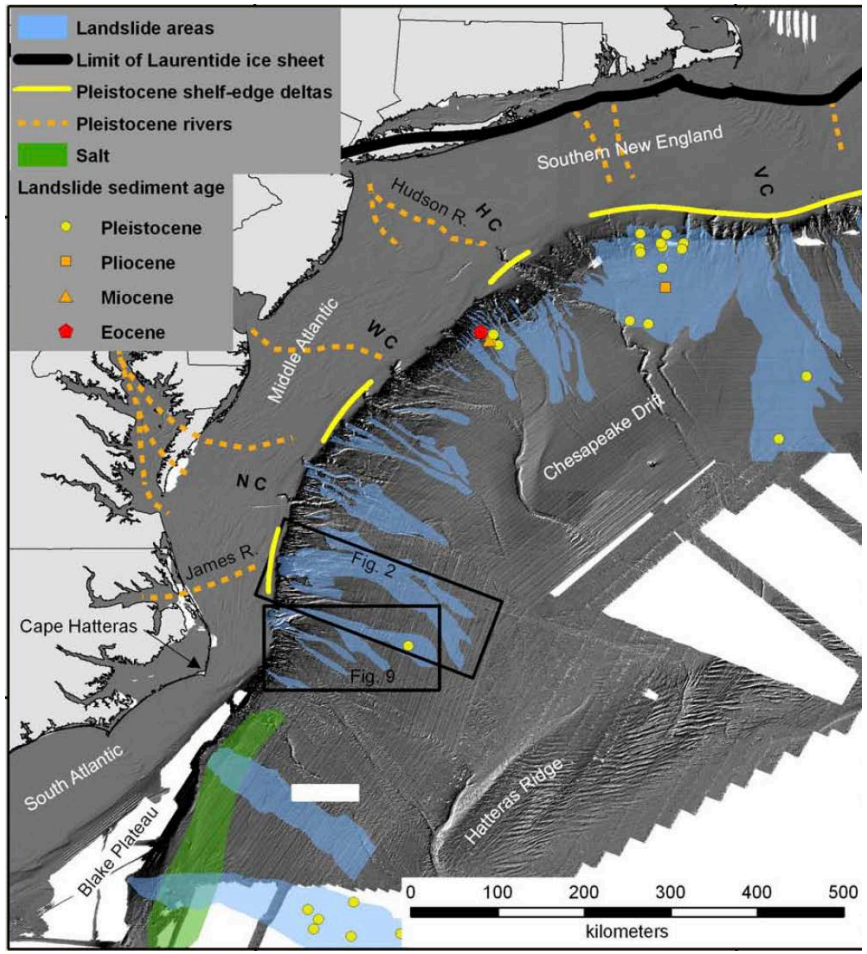
Eastern North American Margin



Withjack et al, 2012



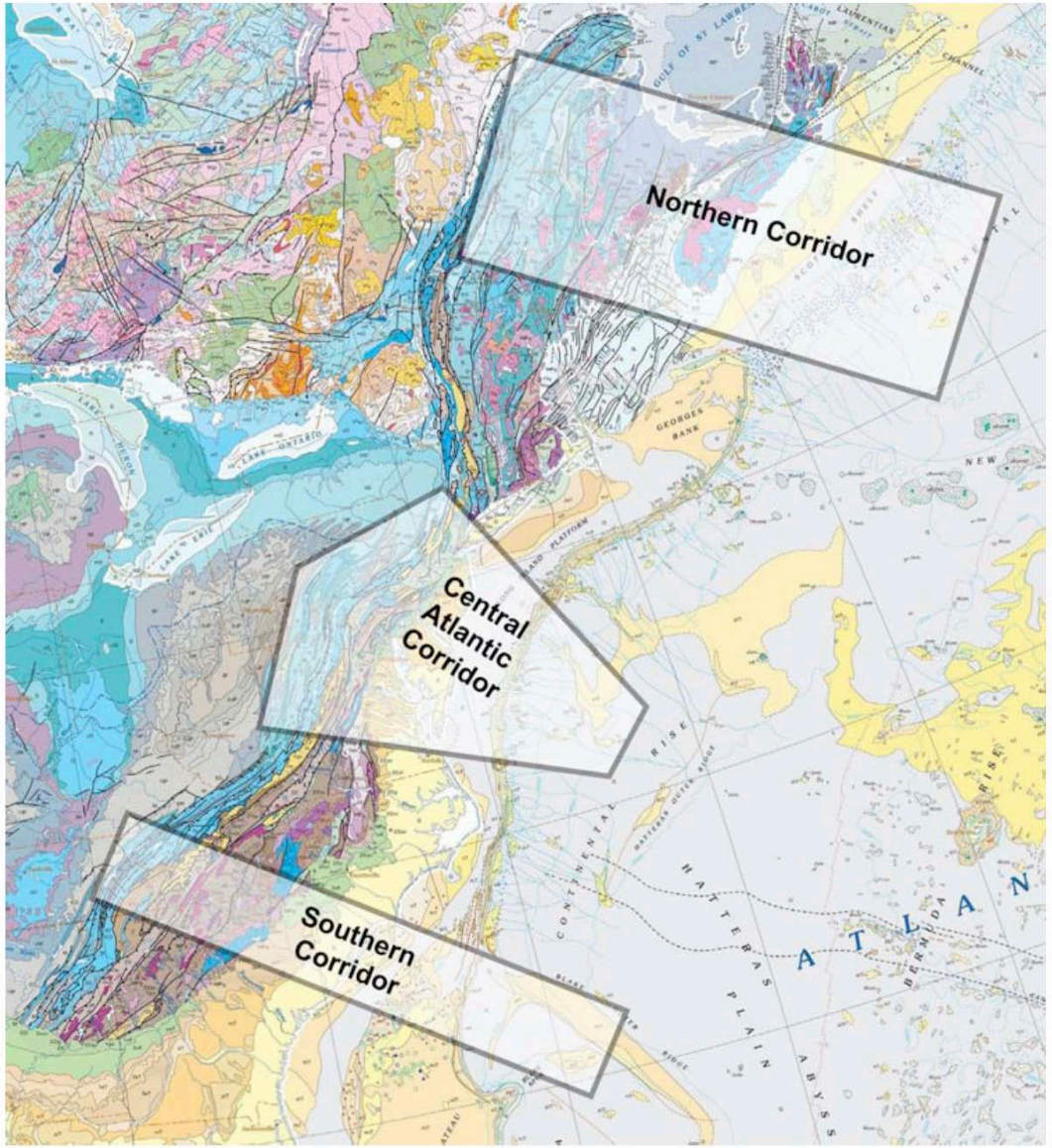
Marzoli et al, 2018



Twitchell et al, 2009

Eastern North American Margin

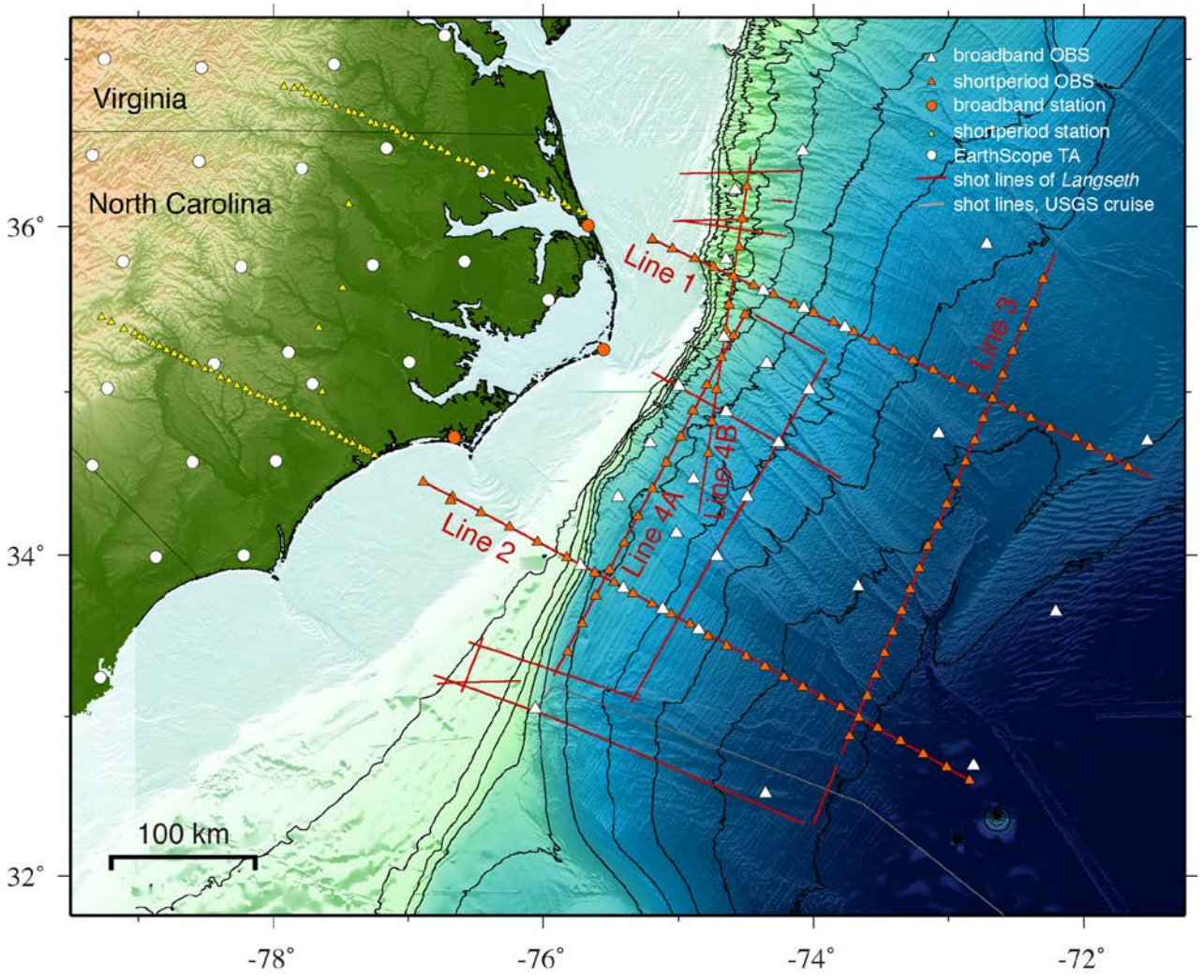
- The role of tectonic and magmatic inheritance in rifting and rift evolution
- The role of magmatism in rifting, breakup, and post-rift lithospheric evolution
- The relationships between breakup, rift-related magmatism, and CAMP
- The along-strike transition from magma-rich to magma-poor extension at breakup
- The evolution of segmentation from initial rifting to mature seafloor spreading
- Mass and elemental fluxes into and out of the sedimentary wedge
- Factors that control offshore landslides and their distribution
- Post-rift margin evolution, drivers and responses: subsidence, epeirogeny, dynamic topography, landscape evolution, erosion, deposition
- Relationships between rift structures and seismic hazard within ENAM
- Understanding the passive-margin sedimentary record: comparative studies of exposed and buried margin sedimentary sequences



Examples of ENAM-focused research

- ENAM Community Seismic Experiment, 2014-2015
  - Data enabling studies of margin structure and processes across temporal and spatial scales, from slope failure to lithospheric structure
- Geochemical studies of age and origin of magmatism
- Slope stability and submarine landslides
- Complementary EarthScope studies of orogenic processes that preceded extension, onshore rift basins, etc
- Complementary USGS studies of rift and postrift margin evolution
- *Funding for work in this primary site has come from a range of NSF programs, including EarthScope, GeoPRISMS, and more, and from USGS*

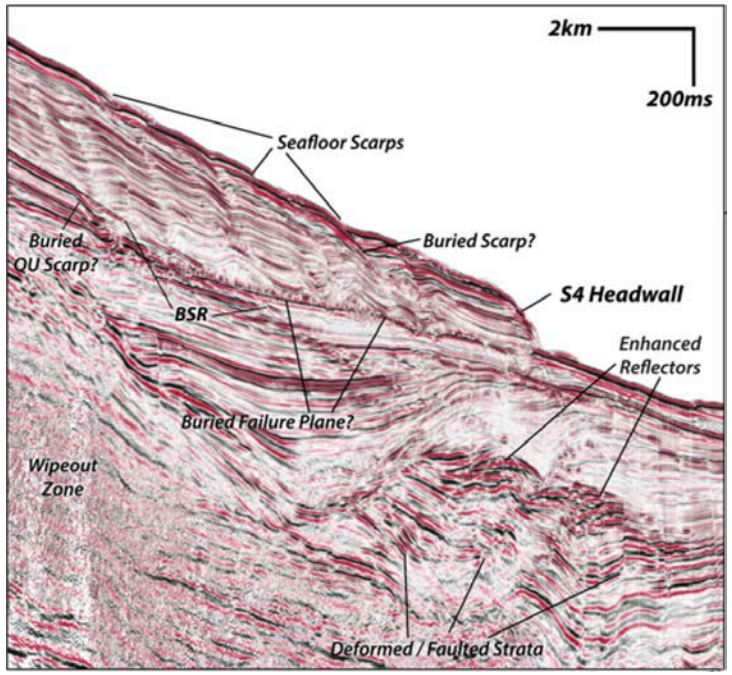
The Eastern North American Margin (ENAM) Community Seismic Experiment



- Deployment of BB OBS in April 2014 and recovery in April 2015 aboard the R/V *Endeavor*
- Deployment of BB onshore stations in May 2014 and recovery in May 2015
- Onshore/offshore active source seismic program on R/V *Langseth*, R/V *Endeavor,* and onland in Sept-Oct 2014
- Onshore active-source experiment in summer 2015

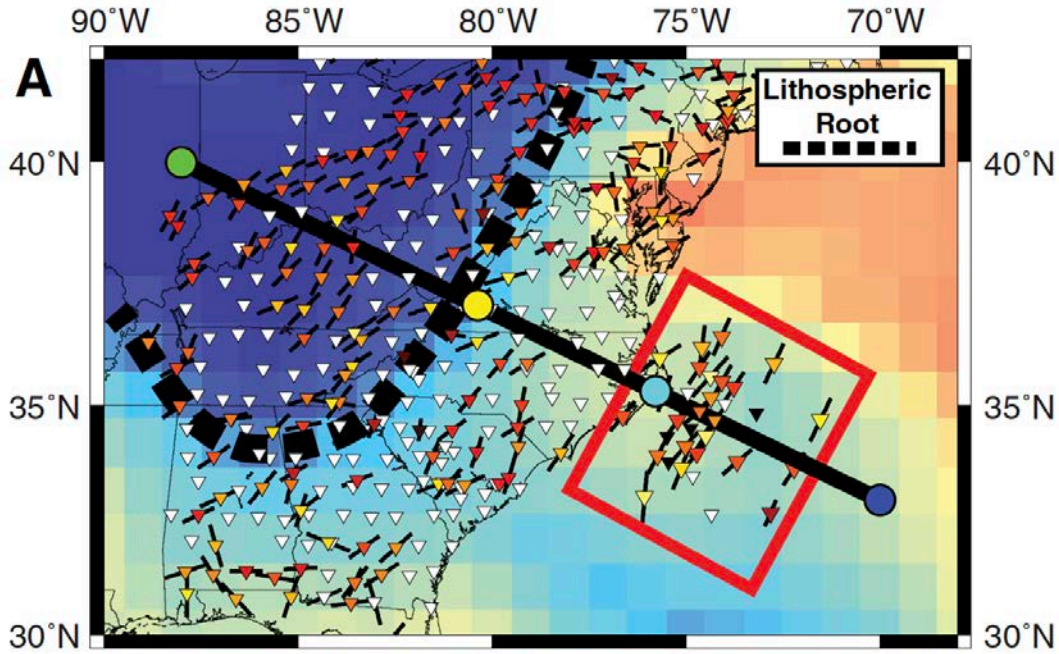
ENAM CSE team: Harm Van Avendonk (UT Austin), Beatrice Magnani (SMU), Donna Shillington (LDEO), Margaret Benoit (TCNJ), Brandon Dugan (Rice), Jim Gaherty (LDEO), Matt Hornbach (SMU), Dan Lizarralde (WHOI), Maureen Long (Yale), Steve Harder (UTEP), Anne Becel (LDEO), Gail Christeson (UT Austin). Lara Wagner (UNC/DTM)

- 79 scientists and students from 49 universities participated in field work
- Training workshops in active source seismology held at UTIG and LDEO which 34 people in total attended



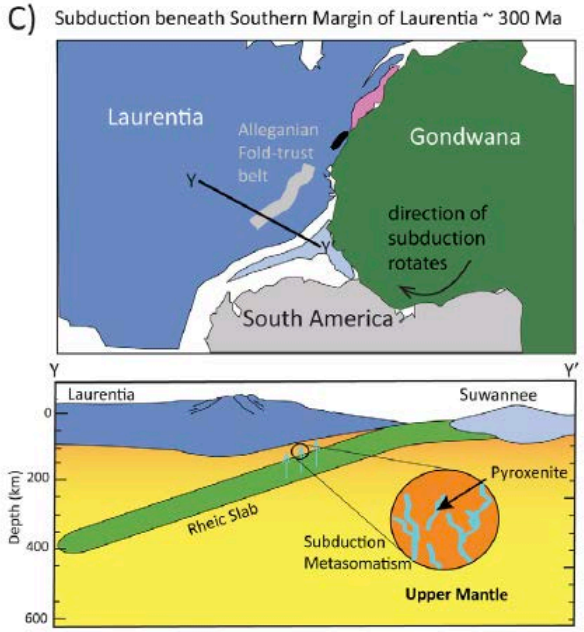
Hill, Brothers et al, GSL, 2017

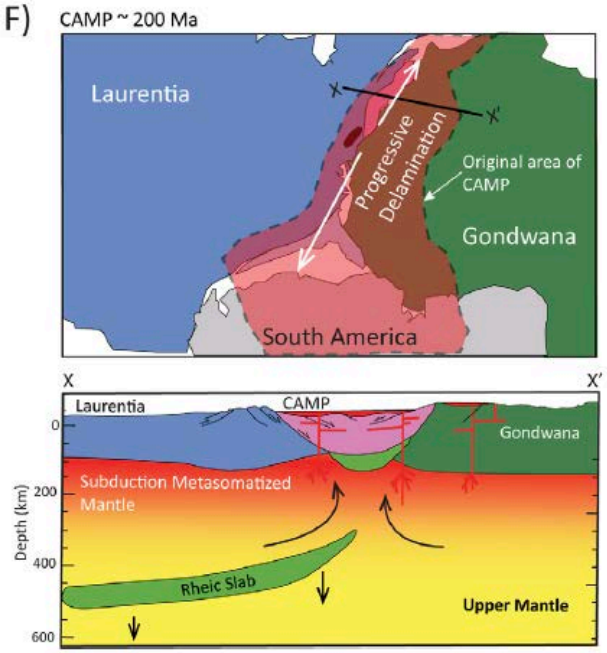
Imaging of margin structure and processes across temporal and spatial scales using ENAM CSE data



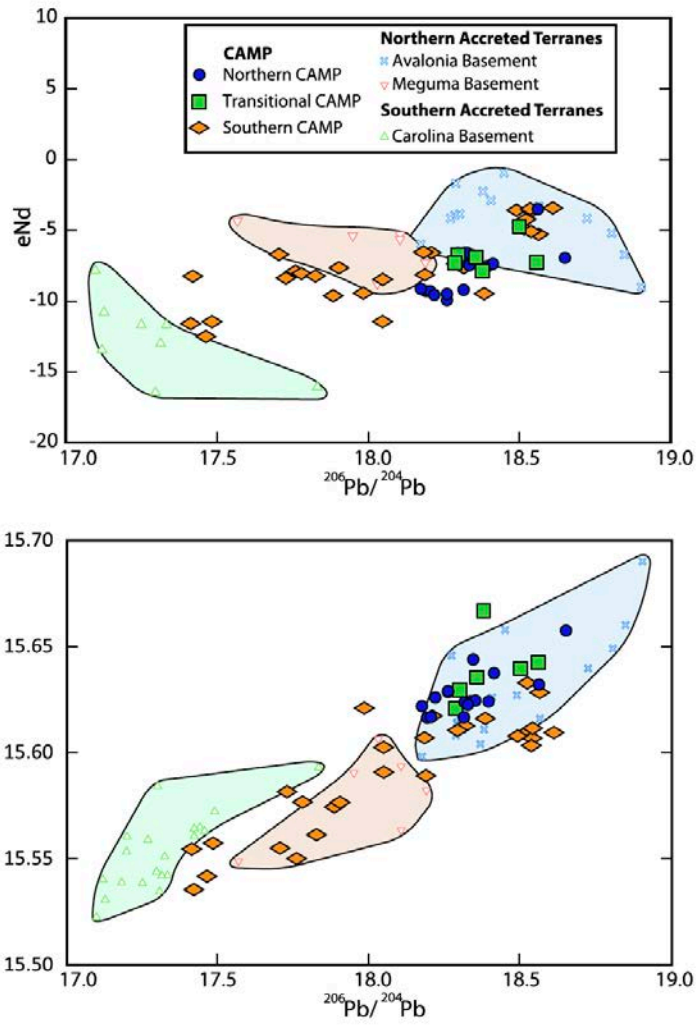
Lynner et al, Geology, 2017

Age and origin of CAMP and post-rift magmatism

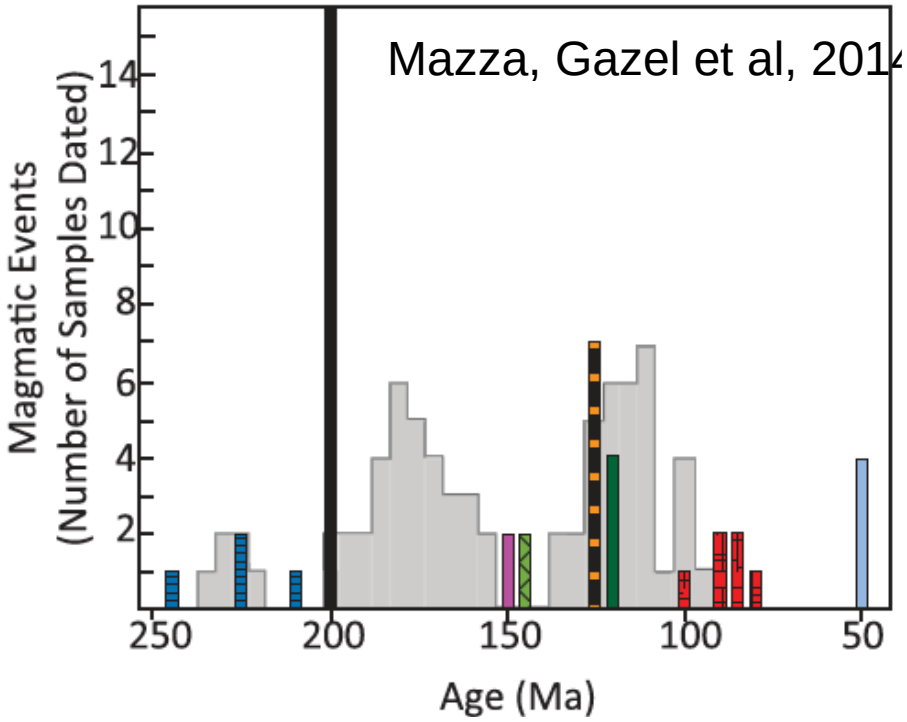


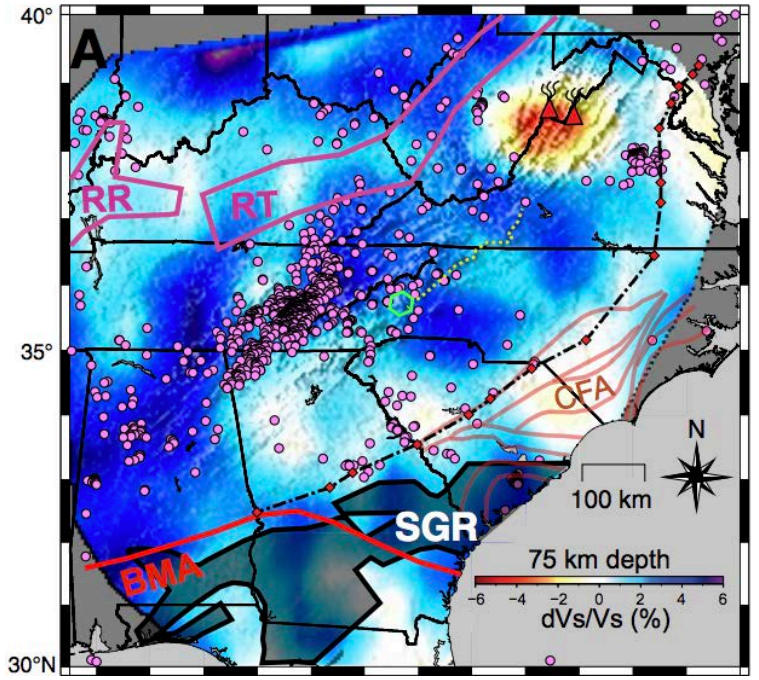


Whalen, Gazel et al, 2015



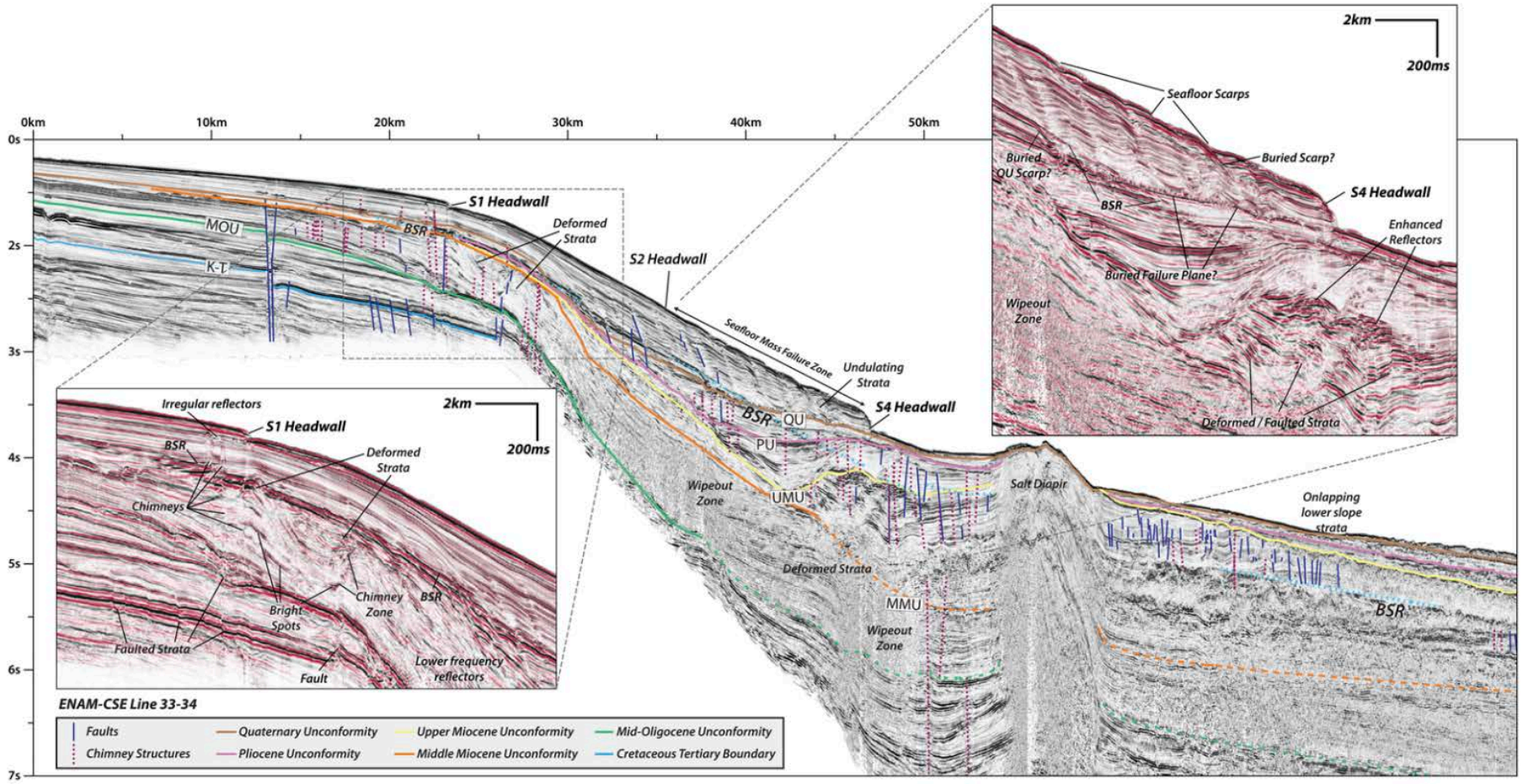
Mazza, Gazel et al, 2014





Wagner, Fischer et al, 2016

Link between postrift sedimentary history and recent slope stability



Hill, Brothers et al, GSL, 2017

East Africa Rift System

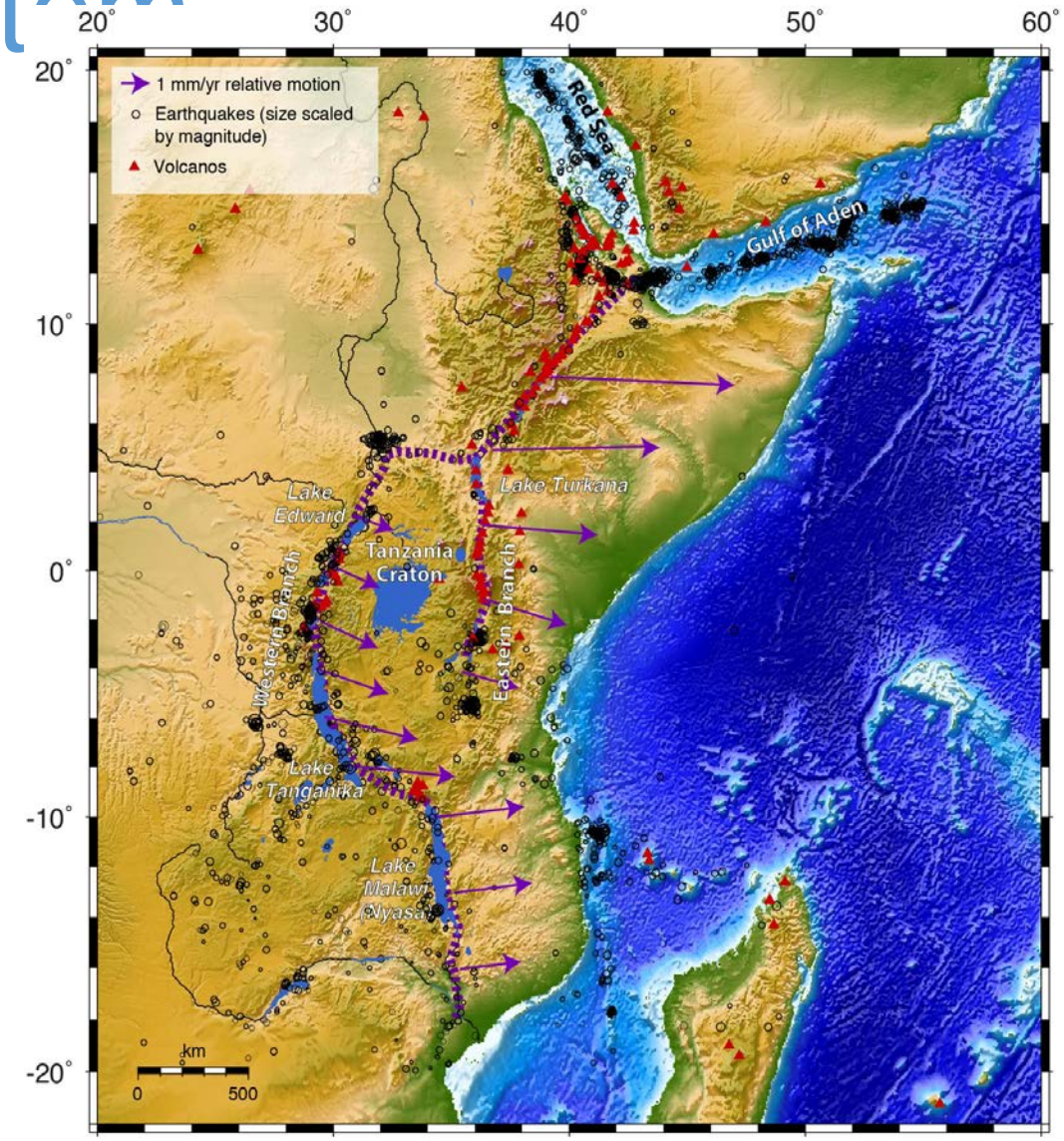
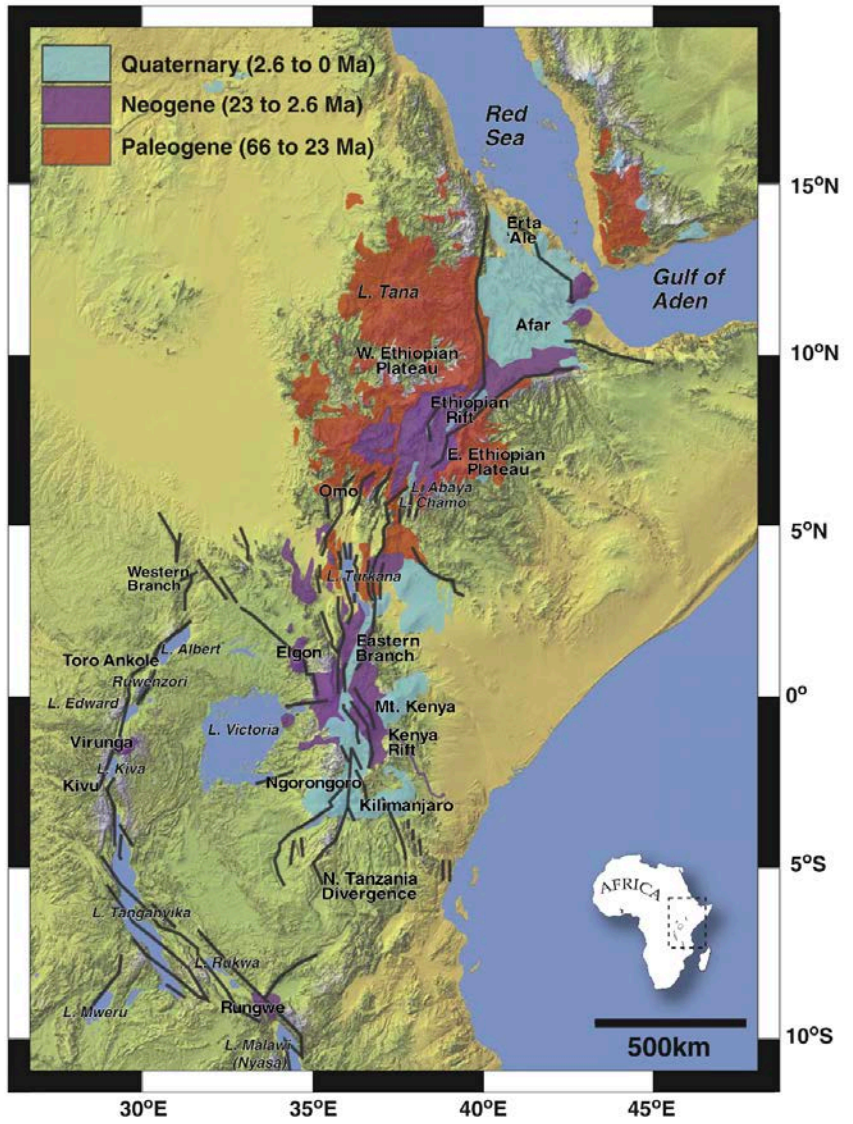


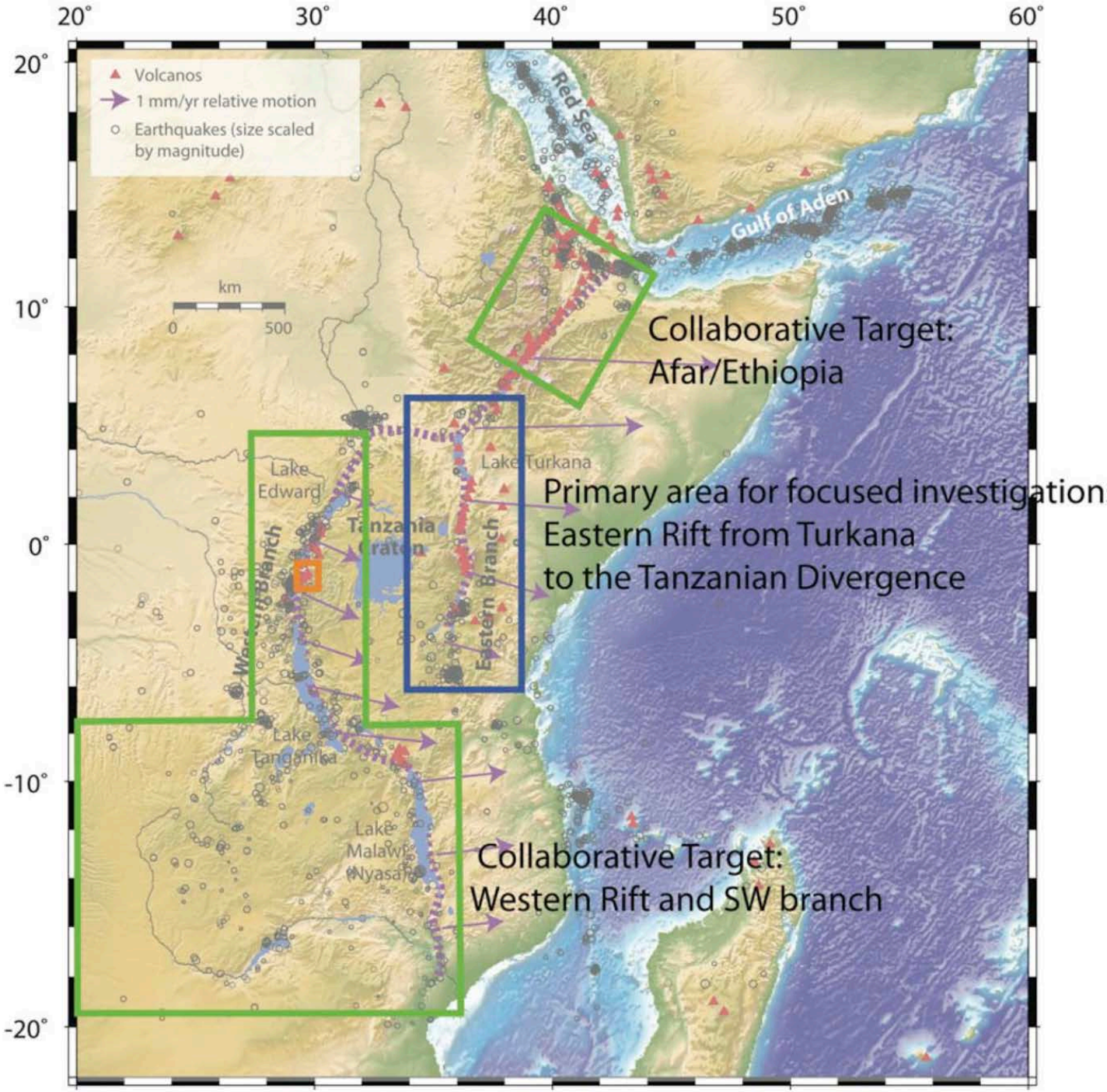
Plate Motions: Stamps et al., 2008; Volcanoes: Smithsonian Global Volcanism Project Earthquakes:



Rooney, 2017

East Africa Rift System

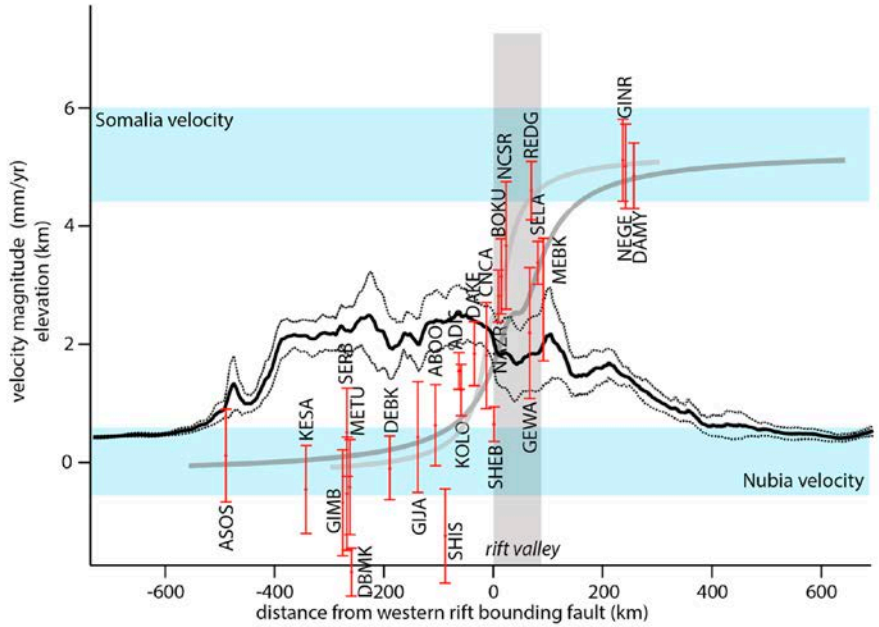
- How does the presence or absence of an upper-mantle plume influence extension?
- How does the mechanical heterogeneity of continental lithosphere influence rift initiation, morphology, and evolution?
- How is strain accommodated and partitioned throughout the lithosphere, and what are the controls on strain localization and migration?
- What factors control the distribution and ponding of magmas and volatiles, and how are they related to extensional fault systems bounding the rift?
- How does rift topography, on either the continental- or basin-scale, influence regional climate, and what are the associated feedback processes?

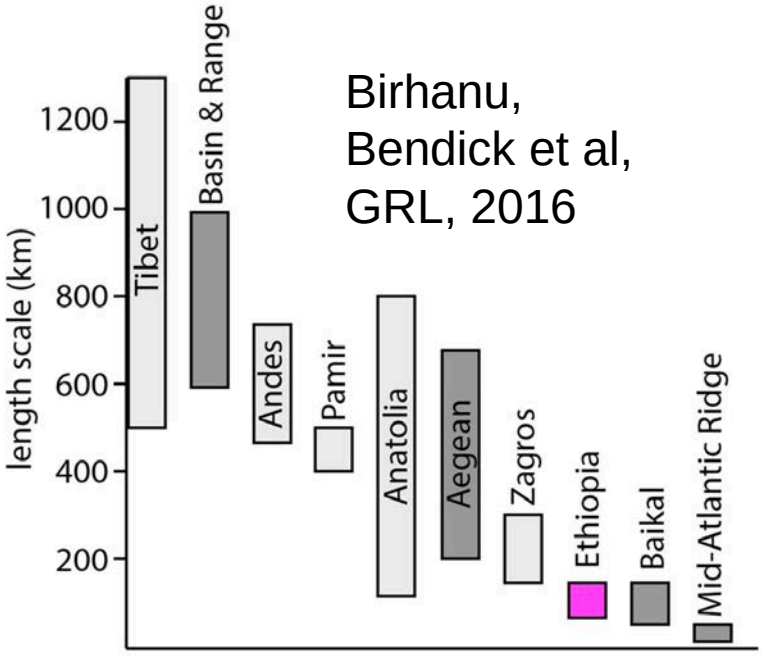


Examples of EARS-focused research

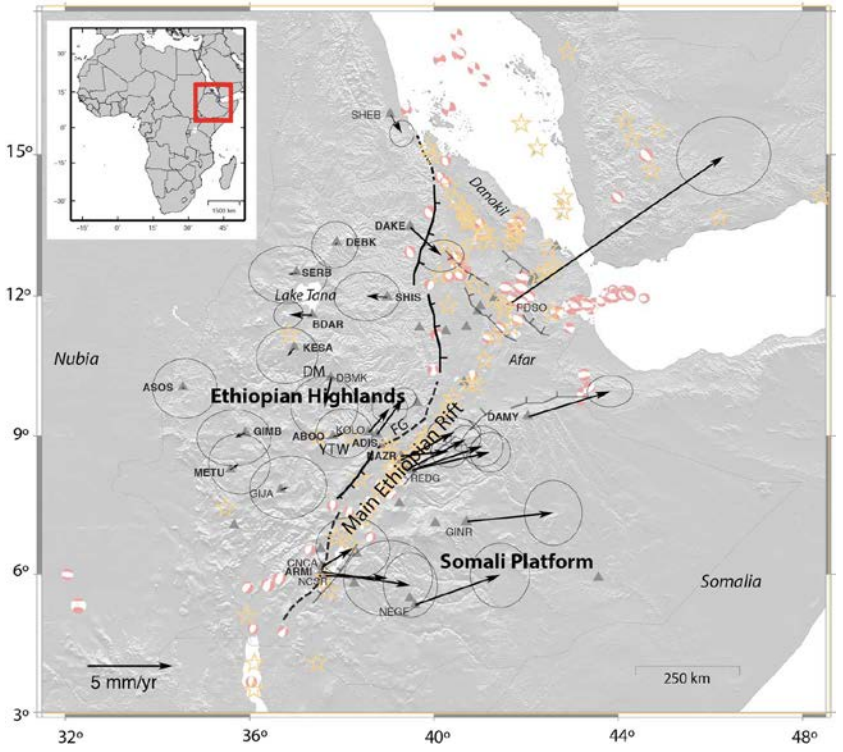
- Recent data collection efforts focused on volatiles, magmatism and deformation in different parts of the EAR (with GeoPRISMS and other funding)
- Geodetic data synthesis and analysis
- Age and origin of magmas within and around rift
- Complementary existing and planned projects in EARS (e.g., CRAFTI, PRIDE, SEGMeNT, TRAILS, others)
- *Funding for work in this primary site has come from a range of NSF programs including Geophysics, Continental Dynamics, IES, GeoPRISMS and others, as well as from international programs*

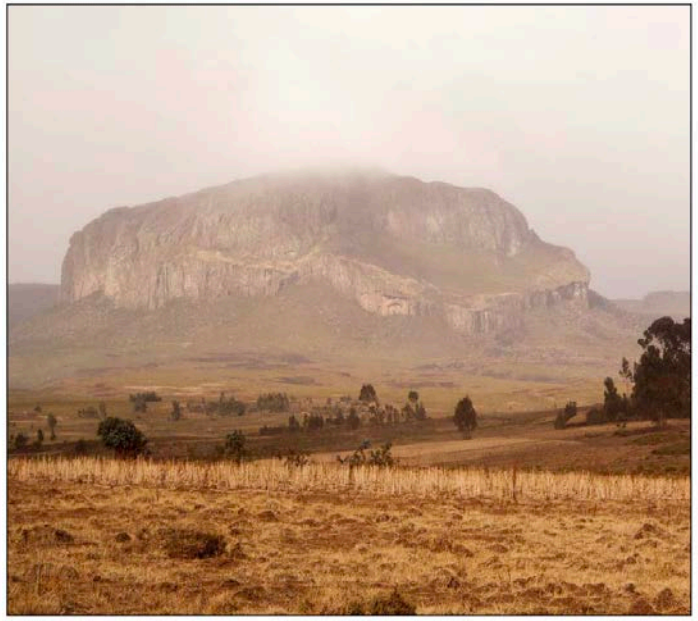
Localization (or not) of deformation and magmatism



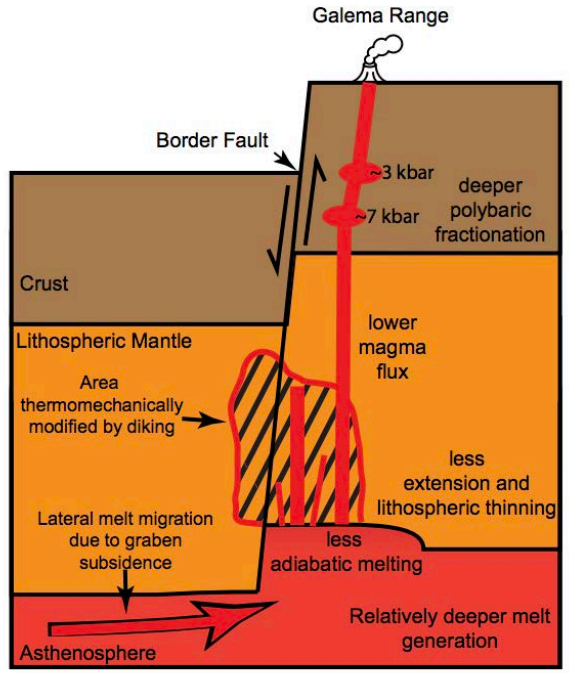


Birhanu, Bendick et al, GRL, 2016

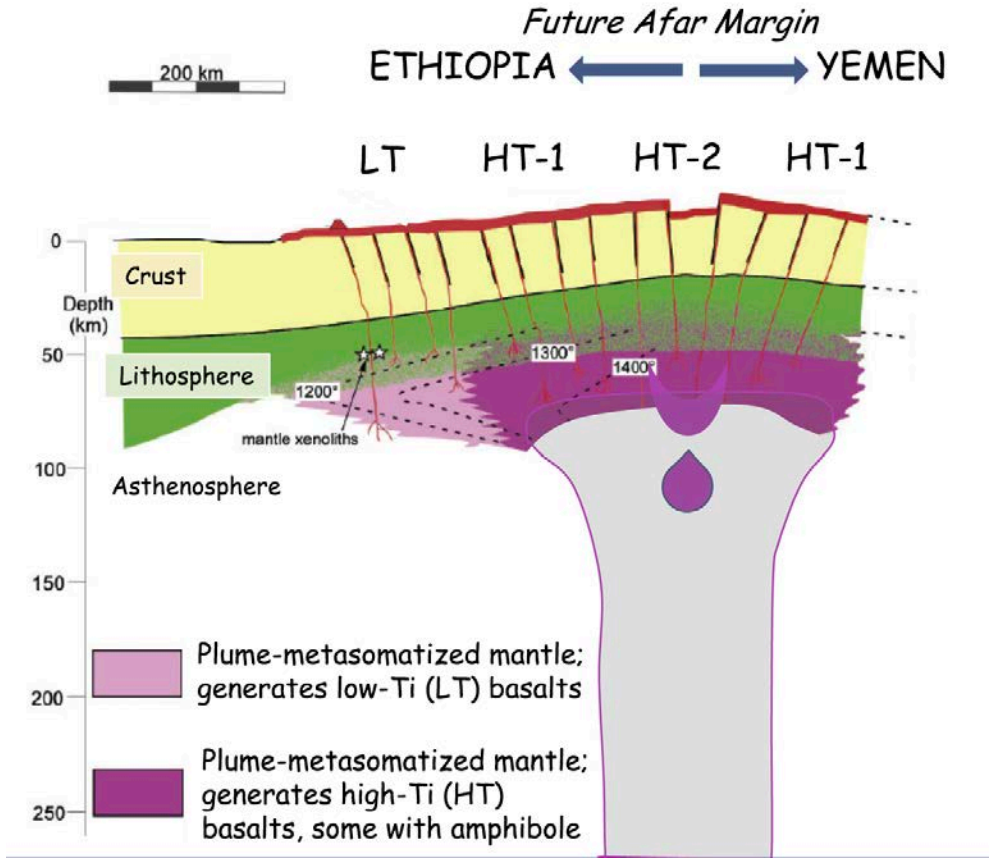




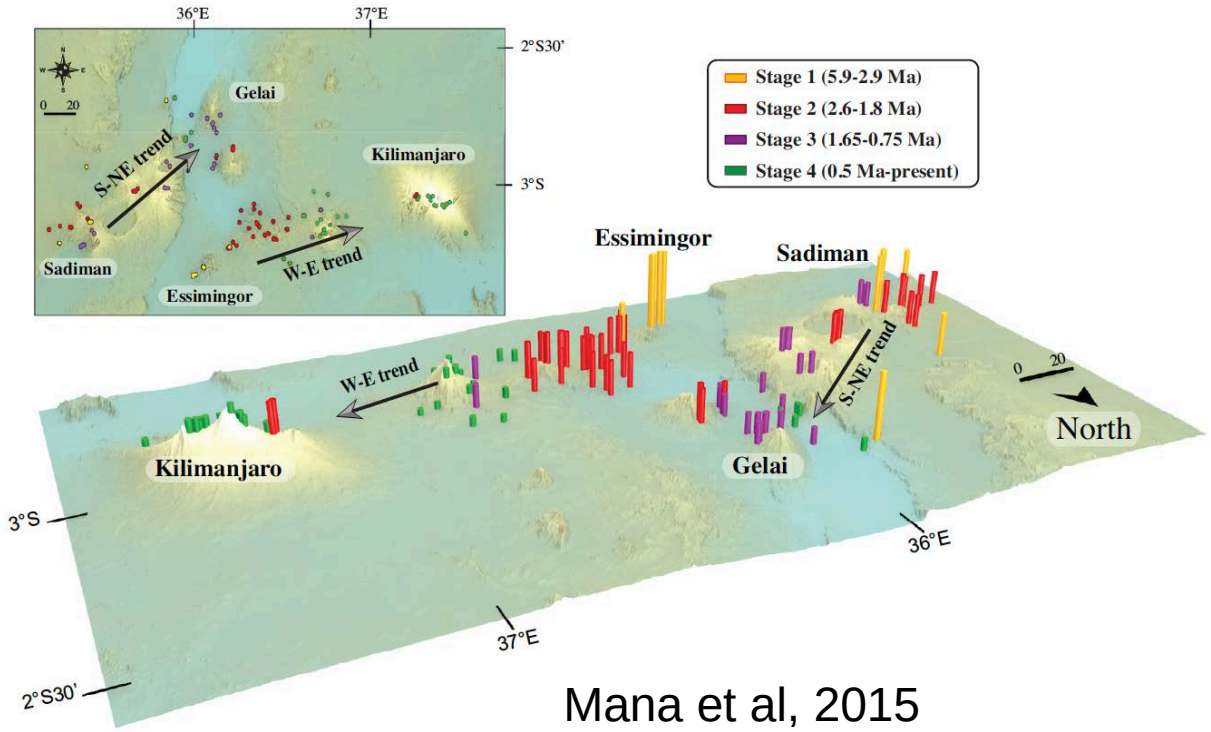
Chiasera, Rooney et al, 2016



Composition, origin and timing of EARS magmatism

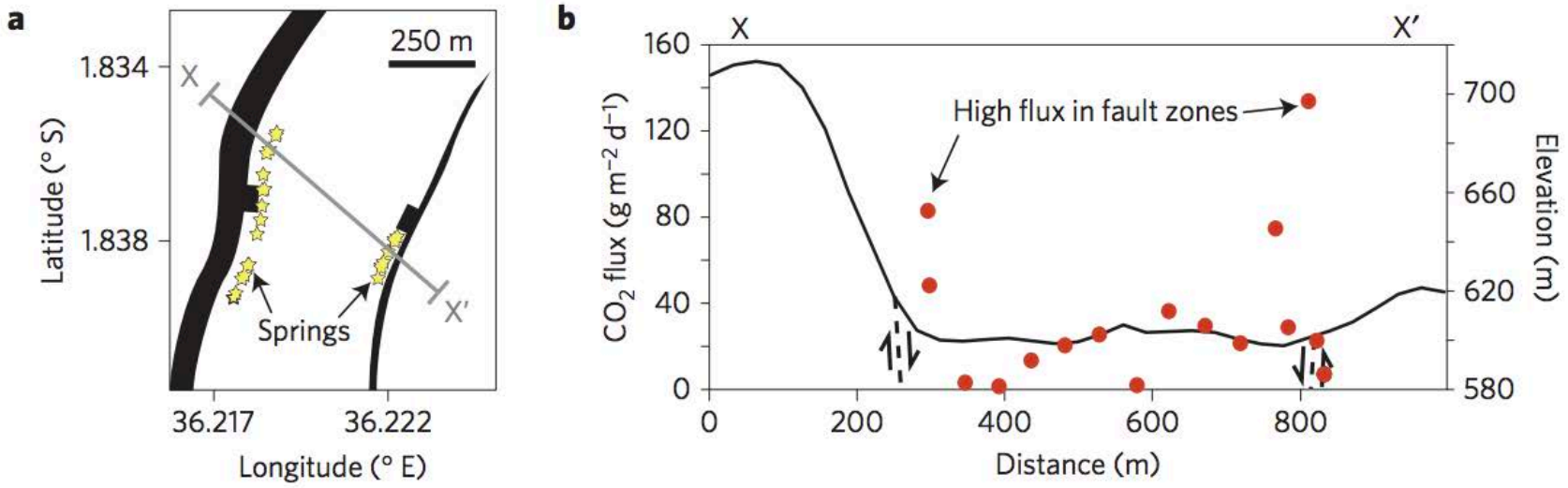


Furman et al., 2016

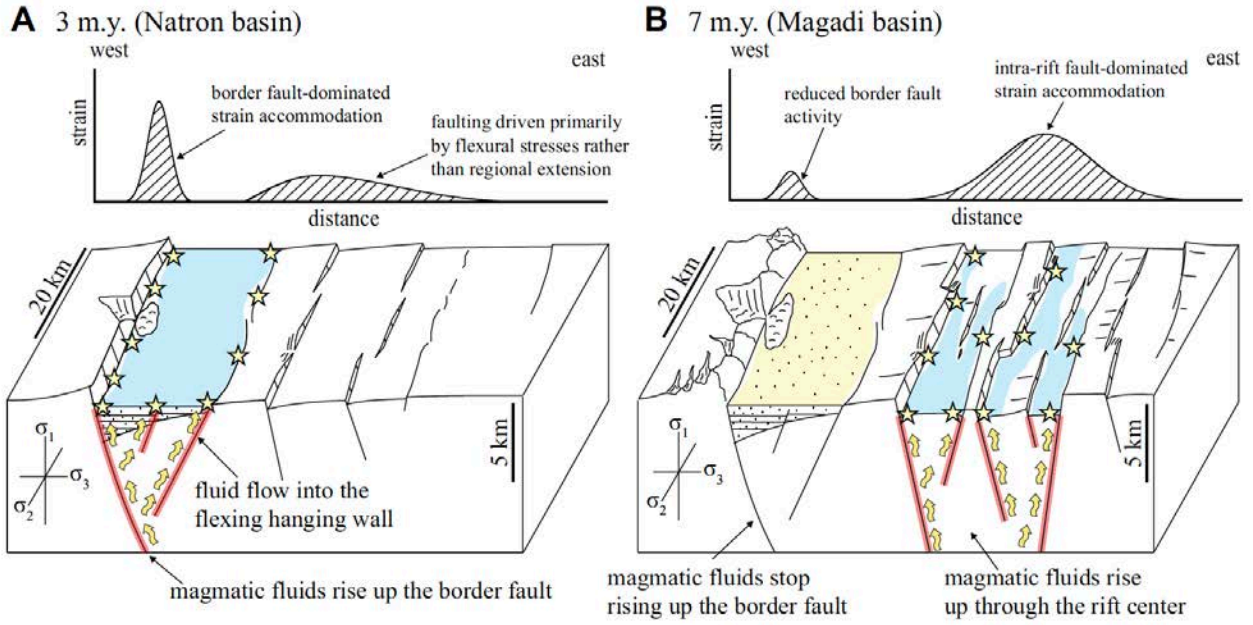


Mana et al, 2015

Volatiles and deformation



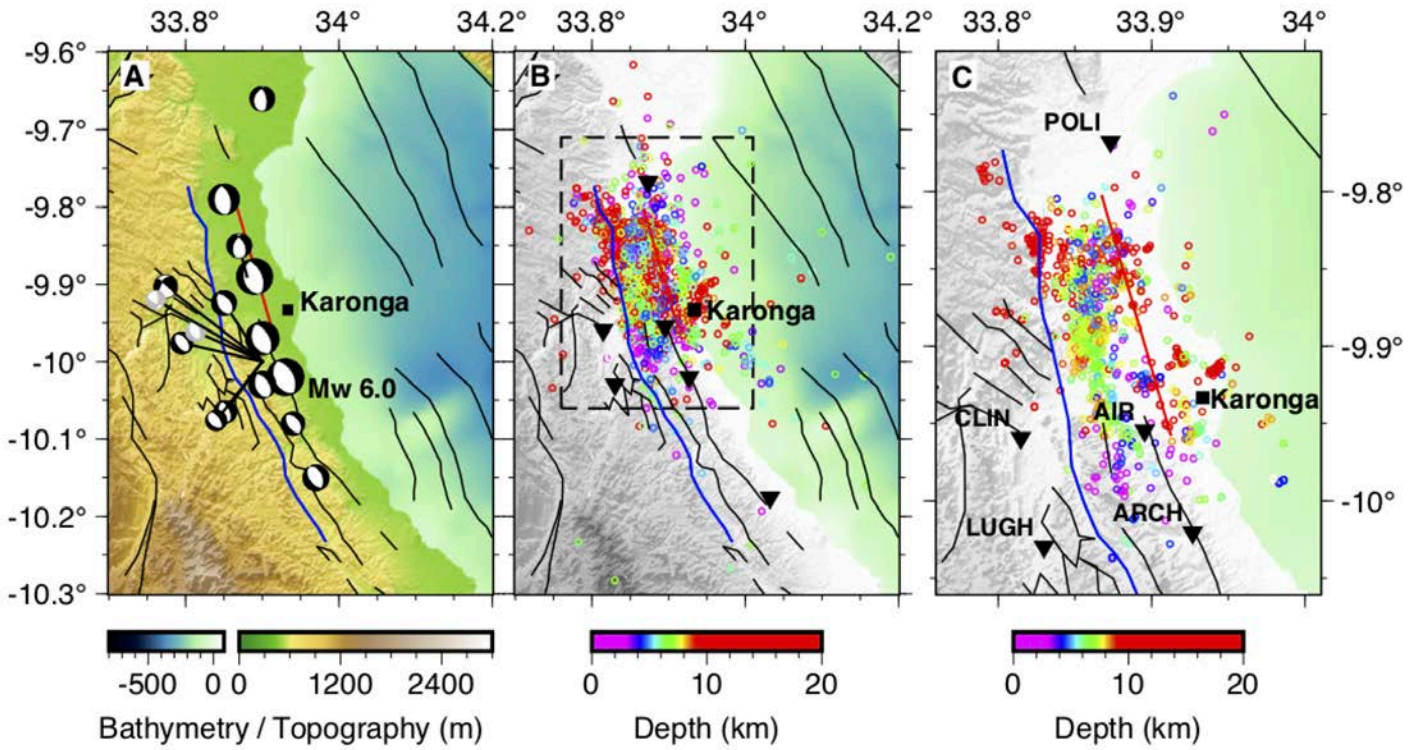
Lee, Fischer et al., *Nature Geoscience,* 2017



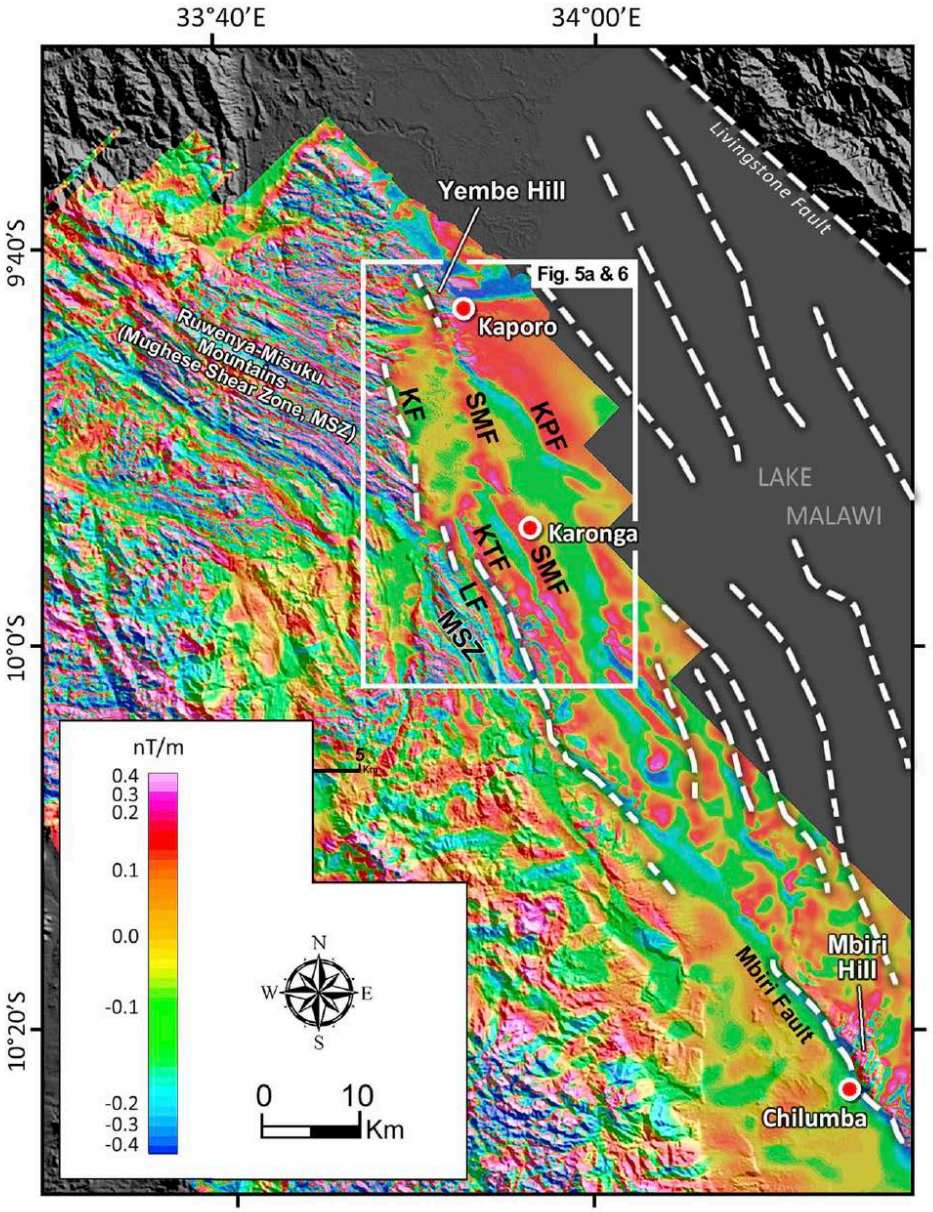
Muirhead, Kattenhorn et al., *Geosphere,* 2017

See James Muirhead's poste

Controls on faulting and seismicity



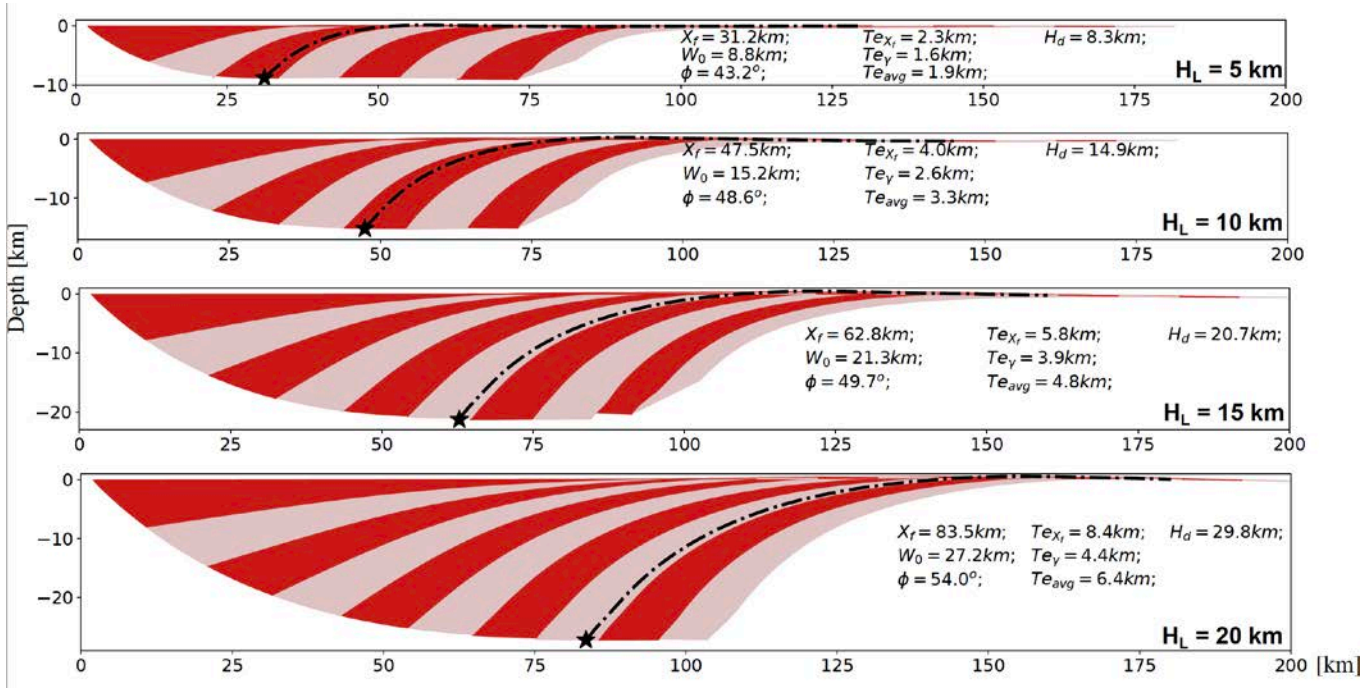
Gaherty et al, GJI, in press



Kolawole, Atekwana et al., Tectonics, 2018

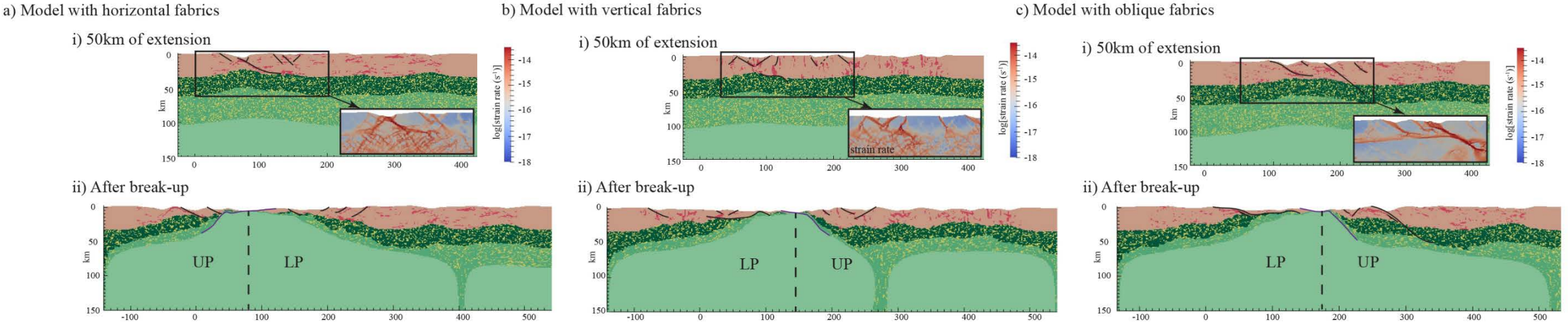
Examples of thematic research

Numerical modeling to understand different aspects of rifted margin development



Tian & Buck, *JGR*, in press

See Xiaochuan Tian's poster



See Suzon Jammes' poster

Jammes & Lavier, *Geosphere*, in press

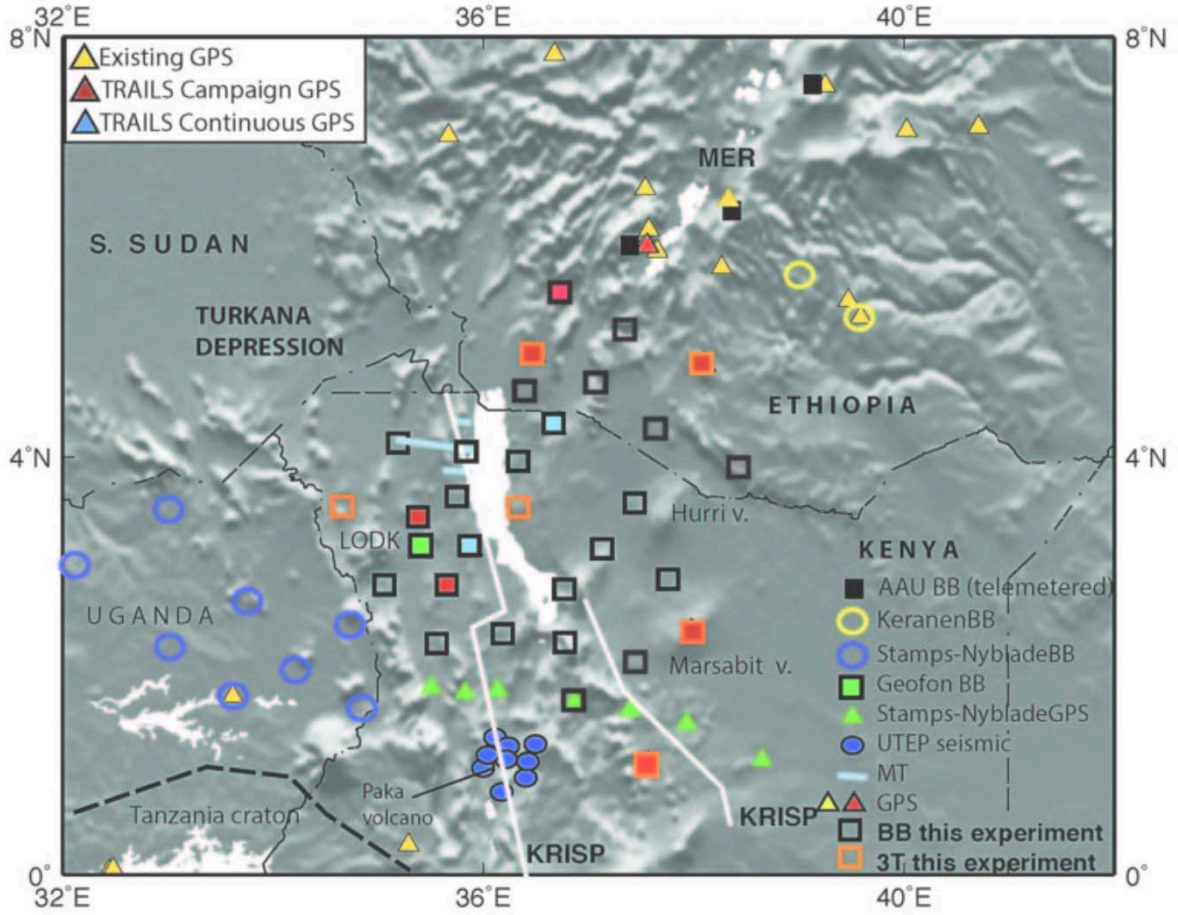
RIE-related work is ongoing and results still to come!

Examples:

Turkana Rift Arrays to Investigate Lithospheric Structure (TRAILS)
NSFGEO-NERC funded project
Bendick, Bastow, Ebinger, Ayele, Lewi

Multi-disciplinary Observations of Degassing and Extensional Tectonics (MODEST)
NSF-GeoPRISMS funded project
Fischer, Muirhead, Scholz, Dufek

TRAILS



High priority areas for future research from 2017 RIE TEI

- Tracking fluids (volatiles and magmas) through the lithosphere and with time
- Controls on deformation and localization at different temporal scales
- Surface mass sedimentary fluxes and feedbacks with rifting

Facilitating strengthening of RIE community

RIE TEI, Feb 2017, Albuquerque

- Student/postdoc symposium: ~65 attendees
- Main meeting:133 attendees, 59 of whom were students and postdocs
- Spanned wide range of expertise, institutions.

Miniworkshops

- 2011: GeoPRISMS Community Seismic Experiment along the ENAM Luncheon
- 2013: Exploring the interplay between solid Earth tectonics and surface processes using community codes
- 2013: Collaborative Efforts in the East African Rift System
- 2015: From rifting to drifting: evidence from rifts and margins worldwide
- 2016: Volcanoes in Extensional and Compressional Settings
- 2017: ENAM science advances: progress and outlook